CLAIMS

1. An optical sensor for measuring an analyte in a biological sample, the sensor comprising a hydrophilic and/or water-swellable polymeric matrix material at least one portion of which includes an analyte-sensitive indicator compound and a cyclic compound which has a three-dimensional structure forming a hydrophobic inner cavity and a hydrophilic exterior surface.

2. An optical sensor according to claim 1, wherein the indicator compound is immobilised in the matrix, and wherein the cyclic compound is associated with the indicator compound.

3. An optical sensor according to claim 1, wherein the cyclic compound is immobilised in the matrix, and wherein the indicator compound is associated with the cyclic compound.

4. An optical sensor according to any of claims 1-3, comprising a layer of the matrix material.

5. An optical sensor according to claim 4, wherein the layer of the matrix material constitutes or is incorporated in a membrane of the sensor.

6. An optical sensor according to claim 1, wherein the polymeric matrix material is selected from the group consisting of cellulose and cellulose derivatives such as isopropylcellulose, carboxymethylcellulose, cyanoethylcellulose or cellulose acetate; a polysaccharide such as carrageenan, tragacanth gum, pectin, pullulan, xanthan gum, amylose or agarose; polyethylene glycol and polyethylene glycol derivatives; polyvinylalcohol; polyacrylamides such as polyacrylamide, poly(N-isopropylacrylamide), or polymethacrylamide; polyacrylic acids and esters thereof such as polyacrylic acid, poly(methacrylic acid), poly(itaconic acid) or polyhydroxyethylmethacrylate; hydrophilic polyurethanes; polyvinylpyrrolidone; polystyrene sulfonic acid; poly(3-morpholinylethylene); poly(N-1,2,4-triazolylethylene); polyvinyl sulfate; polyvinyl amine; poly(γ-glutamic acid); poly(2-ethyl-2-oxazoline); or poly(4-amino-3-sulfoaniline).

7. An optical sensor according to claim 5, wherein the membrane has a thickness in the range of 1-50 μm, such as 5-20 μm, in particular about 8 μm.

8. An optical sensor according to any of claims 1-7 which is adapted to measure one or more analytes in the biological sample, such as pH, concentrations of electrolytes, concentrations of metabolic factors or concentrations of enzymes.

9. An optical sensor according to claim 1, wherein the indicator compound is a hydrophobic, organic compound.

10. An optical sensor according to claim 9, wherein the indicator compound is a light-absorbing or luminescent dye.

11. An optical sensor according to claim 10, wherein the luminescent dye is a fluorescent, phosphorescent or chemiluminescent dye.

12. An optical sensor according to claim 10 or 11, wherein the dye is selected from the group consisting of azo/hydrazone dyes, xanthenes, thioxanthenes, rhodamines, porphyrins, polymethines, e.g. cyanines, coumarines, indoanilines and anthraquinones.

13. An optical sensor according to claim 1, wherein the cyclic compound is a cyclodextrin, a modified calixarene, a cyclic peptide, a carcerand, a cryptophane or a cyclophane, including an azacyclophane.

14. An optical sensor according to claim 13, wherein the cyclodextrin is selected from the group consisting of α-cyclodextrin, β-cyclodextrin, γ-cyclodextrin, hydroxyalkyl substituted cyclodextrin, e.g. hydroxyethyl or hydroxypropyl substituted cyclodextrin, alkyl substituted cyclodextrin, e.g. methyl substituted cyclodextrin, and cyclodextrin substituted with reactive/functional groups, e.g. monochlorotriazine-β-cyclodextrin.

15. A membrane adapted for use in an optical sensor for measuring an analyte in a biological sample, the membrane comprising a hydrophilic and/or water-swellable polymeric matrix material which at least in one portion includes an analyte-sensitive

indicator compound and a cyclic compound which has a three-dimensional structure forming a hydrophobic inner cavity and a hydrophilic exterior surface.

16. A membrane according to claim 15, wherein the indicator compound is immobilised in the matrix, and wherein the cyclic compound is associated with the indicator compound.

17. A membrane according to claim 15, wherein the cyclic compound is immobilised in the matrix, and wherein the indicator compound is associated with the cyclic compound.

18. A membrane according to any of claims 15-17, wherein the cyclic compound is a cyclodextrin, a modified calixarene, a cyclic peptide, a carcerand, a cryptophane or a cyclophane, including an azacyclophane.

19. A membrane according to claim 18, wherein the cyclodextrin is selected from the group consisting of α-cyclodextrin, β-cyclodextrin, γ-cyclodextrin, hydroxyalkyl substituted cyclodextrin, e.g. hydroxyethyl or hydroxypropyl substituted cyclodextrin, alkyl substituted cyclodextrin, e.g. methyl substituted cyclodextrin, and cyclodextrin substituted with reactive/functional groups, e.g. monochlorotriazine-β-cyclodextrin.

20. A membrane according to claim 15, wherein the polymeric matrix material is selected from the group consisting of cellulose and cellulose derivatives such as isopropylcellulose, carboxymethylcellulose, cyanoethylcellulose or cellulose acetate; a polysaccharide such as carrageenan, tragacanth gum, pectin, pullulan, xanthan gum, amylose or agarose; polyethylene glycol and polyethylene glycol derivatives; polyvinylalcohol; polyvinylpyrrolodone; polyacrylamides such as polyacrylamide, poly(N-isopropylacrylamide), or polymethacrylamide; polyacrylic acids and esters thereof such as polyacrylic acid, poly(methacrylic acid), poly(itaconic acid) or polyhydroxyethylmethacrylate; hydrophilic polyurethanes; polystyrene sulfonic acid; poly(3-morpholinylethylene); poly(N-1,2,4-triazolylethylene); polyvinyl sulfate; polyvinyl amine; poly(γ-glutamic acid); poly(2-ethyl-2-oxazoline); or poly(4-amino-3-sulfoaniline).

21. A membrane according to claim 15 which has a thickness in the range of 1-50 μm, such as 5-20 μm, in particular about 8 μm.

22. A membrane according to any of claims 15-21 which is adapted for use in an optical sensor intended to measure one or more parameters in the biological sample, such as pH, concentrations of electrolytes, concentrations of metabolic factors or concentrations of enzymes.

23. A membrane according to claim 15, wherein the indicator compound is a hydrophobic, organic compound.

24. A membrane according to claim 23, wherein the indicator compound is a light-absorbent or luminescent dye.

25. A membrane according to claim 24, wherein the luminescent dye is a fluorescent, phosphorescent or chemiluminescent dye.

26. A membrane according to claim 24 or 25, wherein the dye is selected from the group consisting of azo/hydrazone dyes, xanthenes, thioxanthenes, rhodamines, porphyrins, polymethines, e.g. cyanines, coumarines, indoanilines and anthraquinones.

27. A method of improving the properties of a membrane for use in an optical sensor, the membrane comprising a hydrophilic and/or water-swellable polymeric matrix material at least one portion of which includes an analyte-sensitive indicator compound, the method comprising contacting the indicator compound with a cyclic compound which has a three-dimensional structure forming a hydrophobic inner cavity and a hydrophilic exterior surface for a sufficient period of time to form an association of the indicator compound with the cyclic compound.

28. A method according to claim 27, wherein the cyclic compound is a cyclodextrin, a modified calixarene, a cyclic peptide, a carcerand, a cryptophane or a cyclophane, including an azacyclophane.

29. A method according to claim 28, wherein the cyclodextrin is selected from the group consisting of α-cyclodextrin, β-cyclodextrin, γ-cyclodextrin, hydroxyalkyl substituted cyclodextrin, e.g. hydroxyethyl or hydroxypropyl substituted cyclodextrin, alkyl substituted cyclodextrin, e.g. methyl substituted cyclodextrin, and cyclodextrin substituted with reactive/functional groups, e.g. monochlorotriazine-β-cyclodextrin.

30. A method according to claim 27, wherein the indicator compound is immobilised in the matrix material, and the matrix material is subsequently immersed in an aqueous solution of the cyclic compound for a sufficient period of time to effect association of the cyclic compound with the indicator compound.

31. A method according to claim 27, wherein the cyclic compound is added to the matrix material comprising the indicator compound prior to preparing the membrane from the matrix material.

32. A method according to claim 27, wherein the cyclic compound is immobilised in the matrix material followed by association of the indicator compound with the cyclic compound.

33. A method according to claim 27, wherein the indicator compound is a hydrophobic, organic compound.

34. A method according to claim 33, wherein the indicator compound is a light-absorbing or luminescent dye.

35. A method according to claim 34, wherein the luminescent dye is a fluorescent, phosphorescent or chemiluminescent dye.

36. A method according to claim 34 or 35, wherein the dye is selected from the group consisting of azo/hydrazone dyes, xanthenes, thioxanthenes, rhodamines, porphyrins, polymethines, e.g. cyanines, coumarines, indoanilines and anthraquinones.

37. A method according to claim 27, wherein the polymeric matrix material is selected from the group consisting of cellulose and cellulose derivatives such as isopropylcellulose, carboxymethylcellulose, cyanoethylcellulose or cellulose acetate; a polysaccharide such as carrageenan, tragacanth gum, pectin, pullulan, xanthan gum, amylose or agarose; polyethylene glycol and polyethylene glycol derivatives; polyvinylalcohol; polyvinylpyrrolidone; polyacrylamides such as polyacrylamide, poly(N-isopropylacrylamide), or polymethacrylamide; polyacrylic acids and esters thereof such as polyacrylic acid, poly(methacrylic acid), poly(itaconic acid) or polyhydroxyethylmethacrylate; hydrophilic polyurethanes; polystyrene sulfonic acid; poly(3-morpholinylethylene); poly(N-1,2,4-triazolylethylene); polyvinyl sulfate; polyvinyl amine; poly(γ-glutamic acid); poly(2-ethyl-2-oxazoline); or poly(4-amino-3-sulfoaniline).

38. Use of a cyclic compound which has a three-dimensional shape forming a hydrophobic inner cavity and a hydrophilic exterior surface to protect a hydrophobic analyte-sensitive indicator compound in a hydrophilic and/or water-swellable polymeric matrix material of an optical sensor from aggregation in the presence of moisture.

39. Use of a cyclic compound which has a three-dimensional shape forming a hydrophobic inner cavity and a hydrophilic exterior surface to increase the wettability and reduce the brittleness of a hydrophilic and/or water-swellable polymeric matrix material of an optical sensor, which polymeric matrix material includes a hydrophobic analyte-sensitive indicator compound.